Case-Based Reasoning to Enhance Diagnosis and CSP Model Debugging in Interoperability Testing: ADIOP

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This material is based in part on work supported by King Fahd University of Petroleum & Minerals, Science Foundation Ireland, and the National Science Foundation. Some of this work was done while both authors were at the University of New Hampshire.

Outline

- Overview & Example
- Motivations
- CBR/CSP Integration
- Updating CSP Models
- Improving Explanations
- Evaluation
- Summary

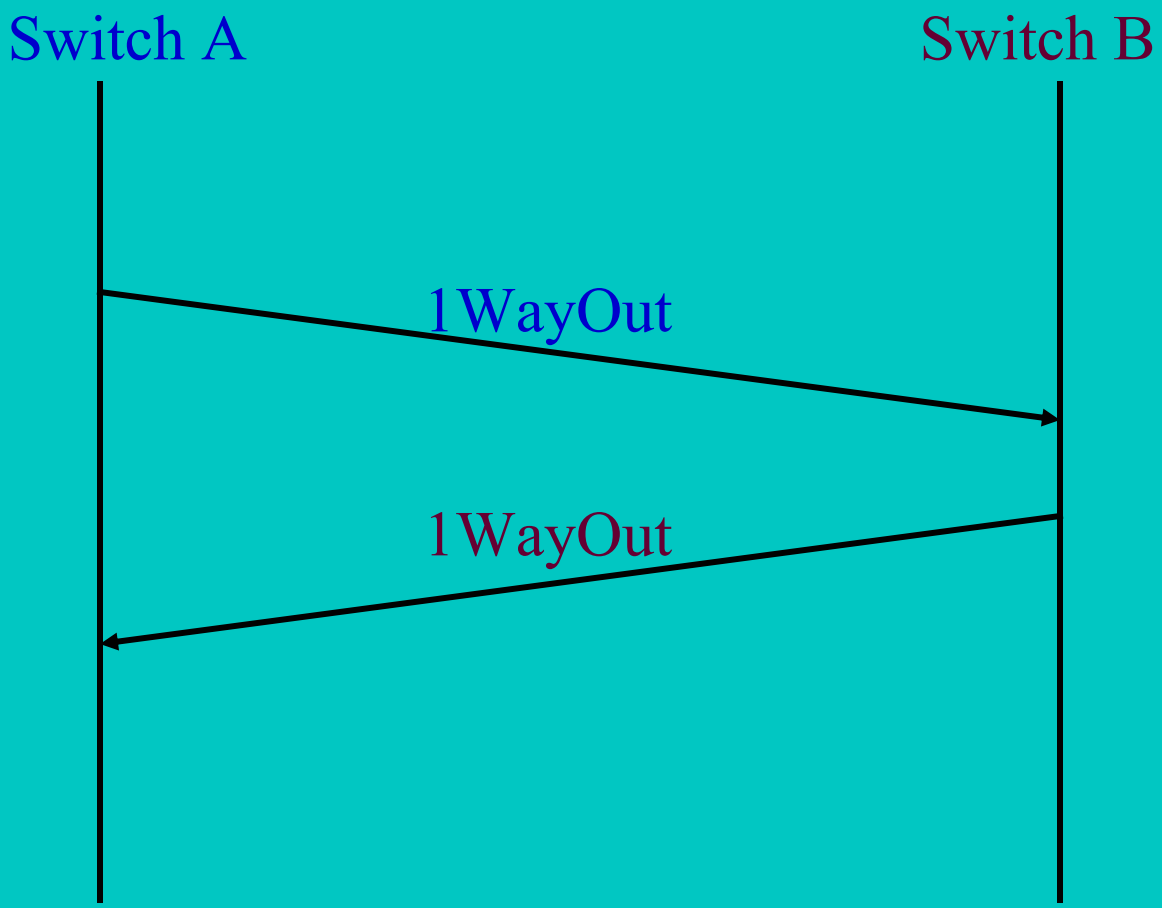
Interoperability Testing

Interoperability Testing <=> Compare (Specifications, Observations)

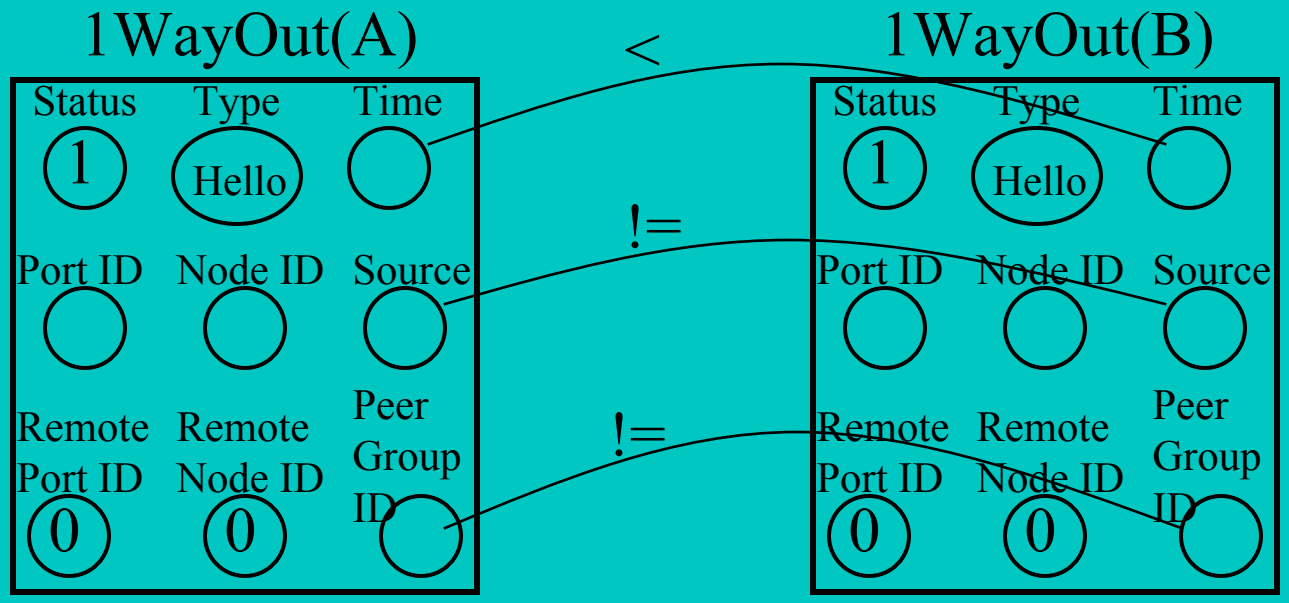
Example from a Test Suite

- Test Case ID: V4202H__004
- Test Purpose: Verify that the first Hello sent from both sides contains Remote node ID and Remote port ID set to zero (1Way).
- Pre-requisite: Both SUTs (A, B) are in different lowest level peer groups (Out).
- Verdict Criteria: The first Hello packet observed from each SUT will have the Remote node ID field and Remote port ID field set to zero (1WayOut).

Example - Test Description

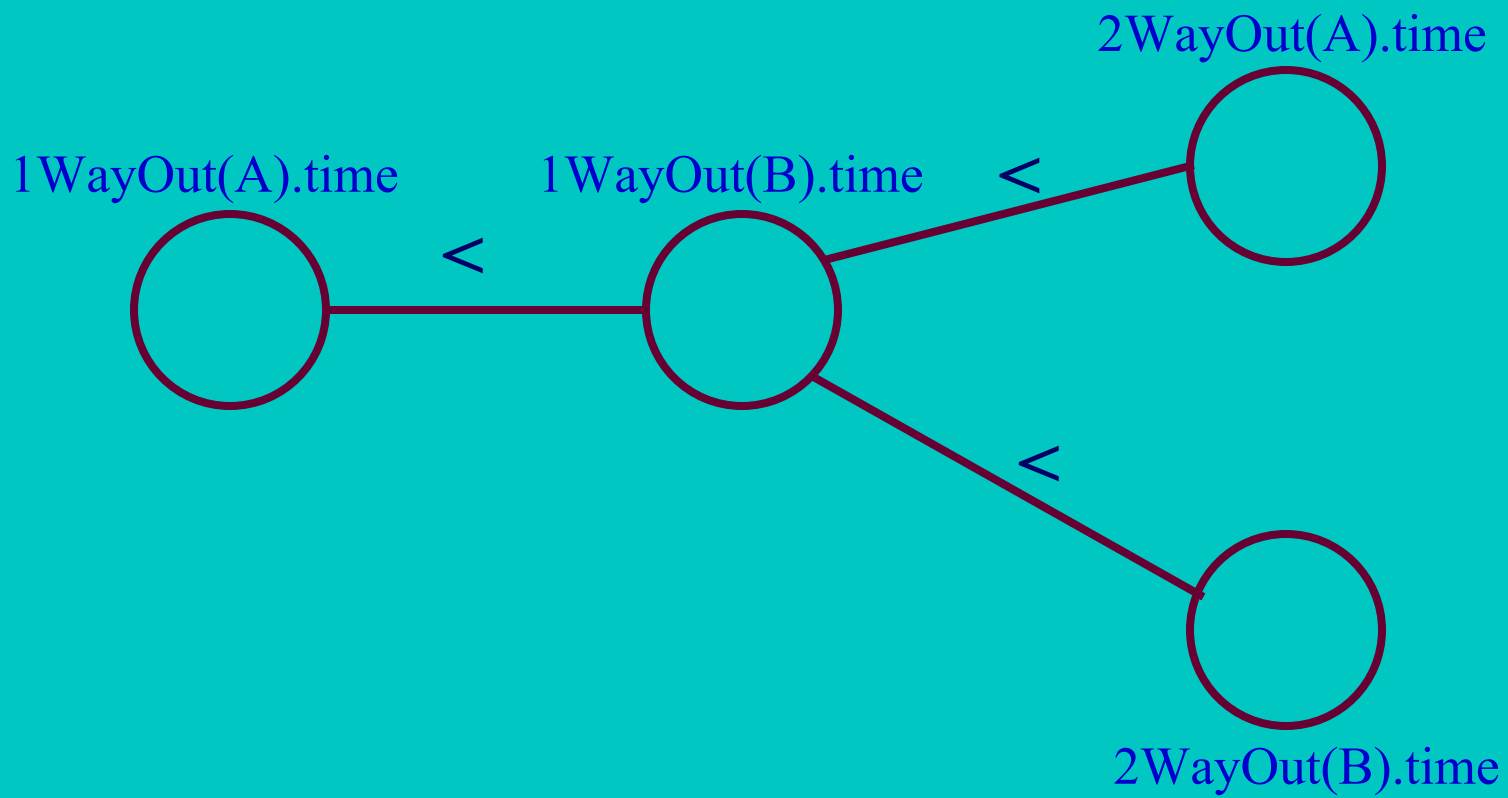


Example - CSP Model

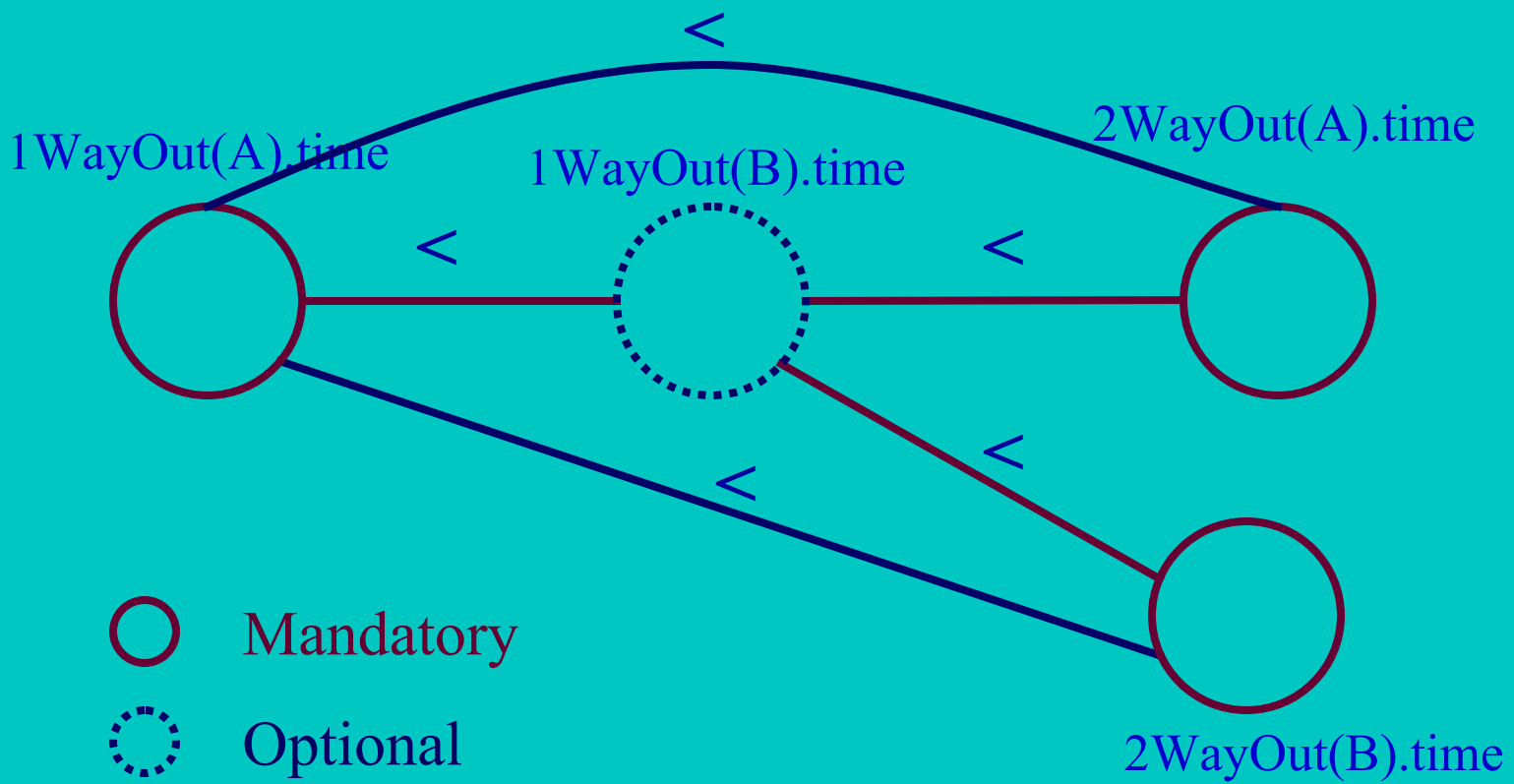


Variables		1WayOut(A) {Source, Time, Status, Node_ID, ...} 1WayOut(B) {Source, Time, Status, Node_ID, ...} ...
Constraints	Unary	1WayOut(A).Status = Mandatory 1WayOut(A).Remote_Node_ID != 0
	Binary	1WayOut(A).Time < 1WayOut(B).Time 1WayOut(A).Peer_Group_ID != 1WayOut(B).Peer_Group_ID ...

CSP Model (Time Constraints)



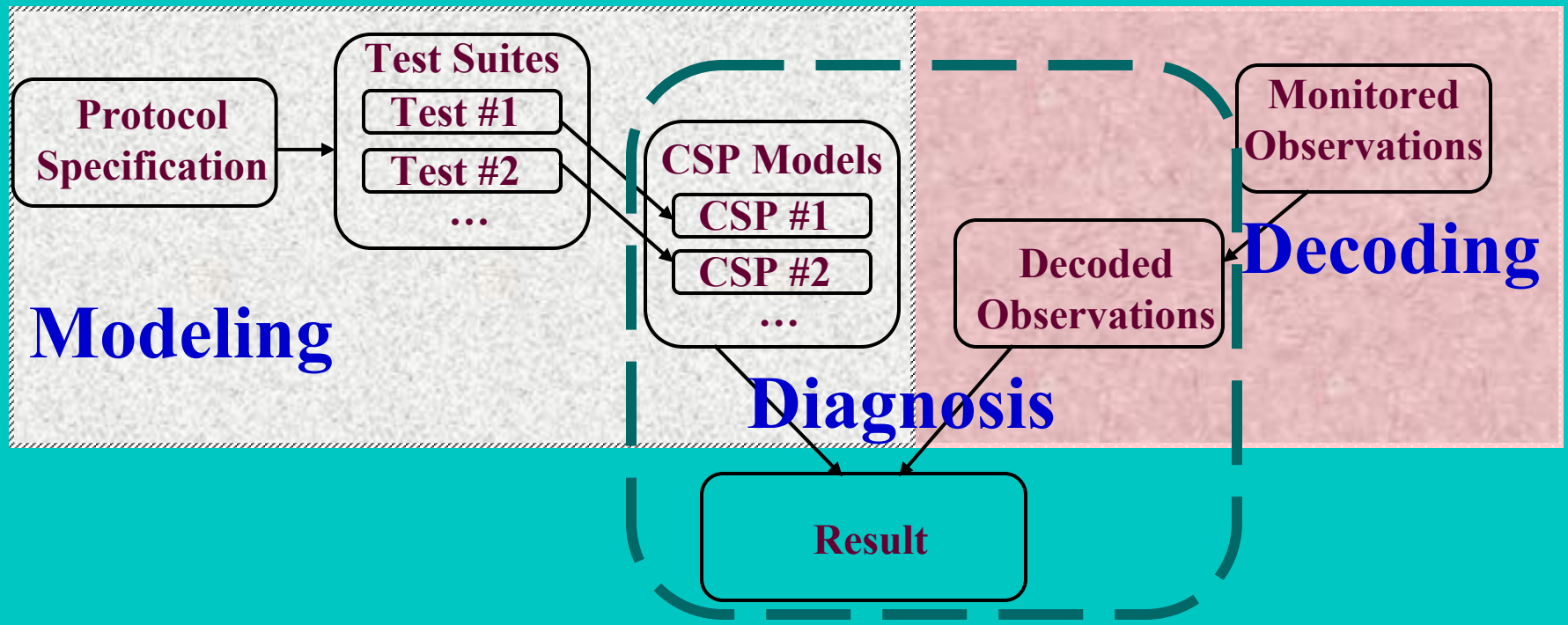
CSP Model Updated



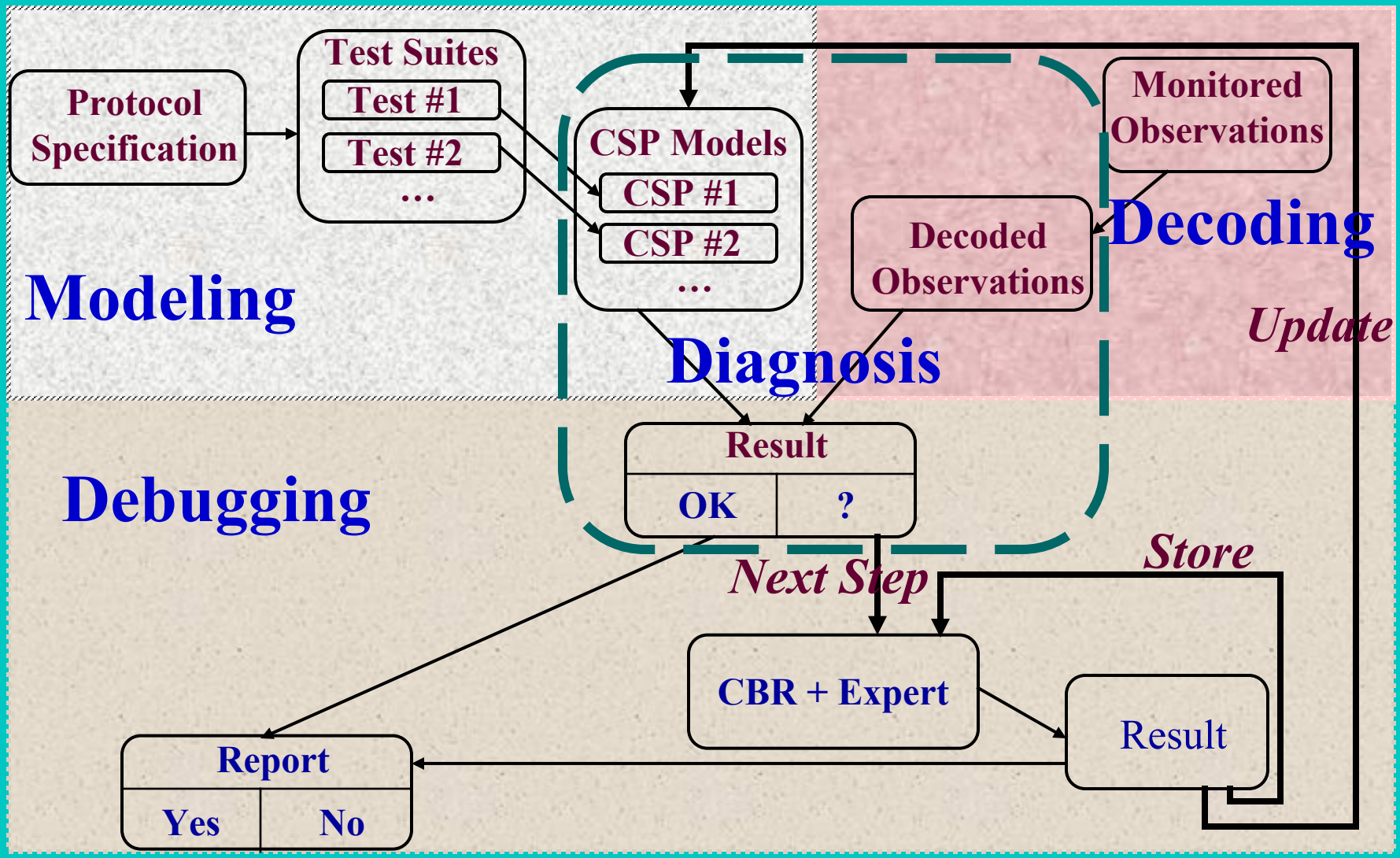
Rules for Updating this CSP Model

- Problem: Missing packet
- Actions taken:
  1. Update the status of the metavariable representing the missing packet to become "Optional"
  2. Add transitivity constraints involving the time variable of this packet.

ADIOP – The big picture (Three Modules)



ADIOP – The big picture (Four modules)



Motivations

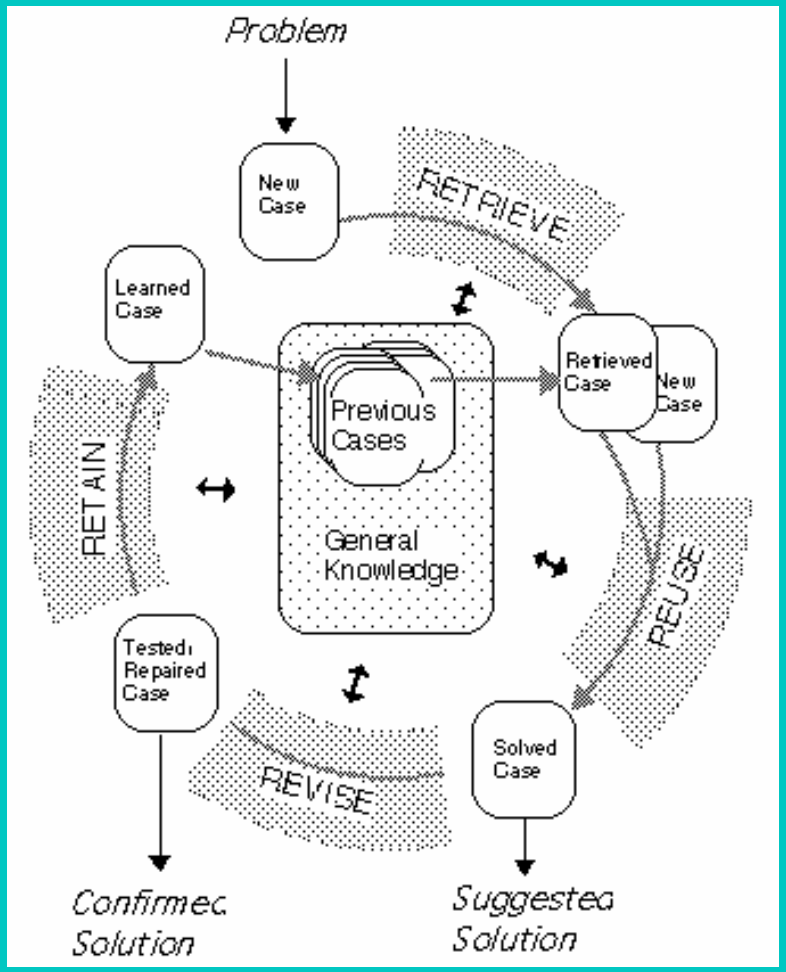
- Debugging models of Interoperability test cases
  - Detect and debug inconsistencies in CSP models built by testers
  - Provide a framework for model acquisition and debugging
  - Enhance test cases correctness and completeness
  - Provide a user friendly interface for retrieving similar cases and updating CSP models
  - Interact with testers to insure consistency of model updates.
  - Integrate easily with the CSP framework including its modeling language
- Improving explanations
  - Retrieve similar past occurrences to solve new problems and provide useful explanation when diagnosis fails

Incompleteness and Incorrectness (Sqalli & Freuder 1998)

- Human errors in writing the protocol specification
- Inconsistencies in different sections of the same specification
- The protocol specification is not well defined, and may be interpreted incorrectly when developing test suites
- Interactions with the external world are unknown
- Modeling of test cases is done by testers and may contain inconsistencies

Case-Based Reasoning

- CBR uses past experience to solve new problems. It is useful because: (Leake 1996)
  - similar problems tend to have similar solutions
  - same types of problems tend to recur
- CBR is a cyclical process comprised of four REs: (Aamodt & Plaza 1994)
  - Retrieve the most similar case(s)
  - Reuse the case(s) to solve the problem
  - Revise the proposed solution if necessary
  - Retain the new solution as a new case

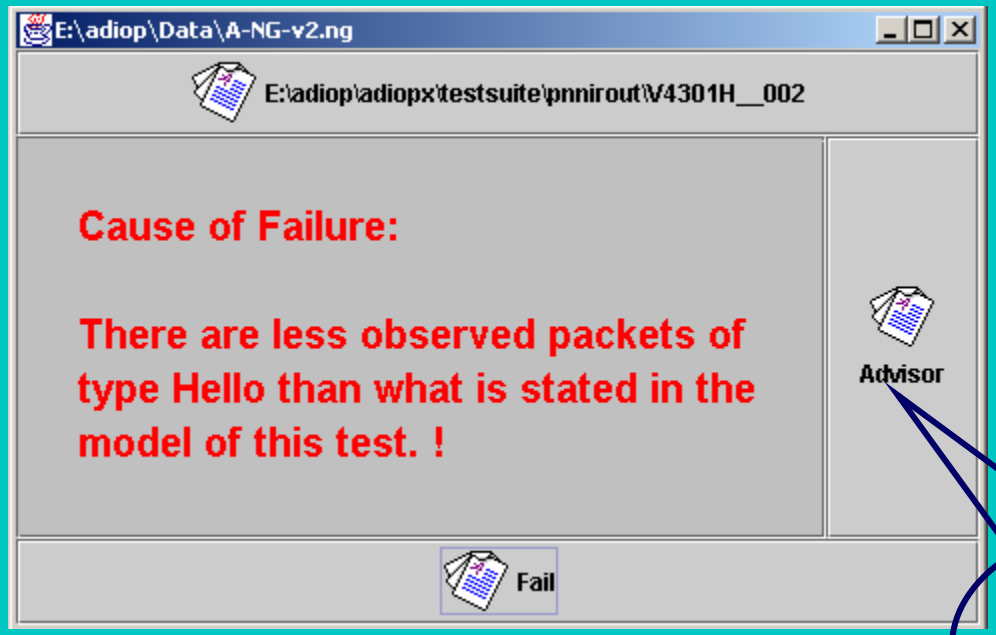


CBR System in ADIOP

- Case base storage: flat-record style database
- Case representation: 14 features (attribute-value pairs) including one for model update
- Case retrieval:
  - Semantical (1 feature) and syntactical similarity measures for computing distances between features.
  - N-grams are used for syntactical similarity
  - Weights are based on empirical data
  - Global similarity is computed using a nearest neighbor retrieval equation
- Case Reuse and Adaptation: basic rules for adaptation, and the tester confirms the adaptation results
- Case revision: is done manually by testers to finalize outcome
- Case Retention: the case is eventually stored in the case base (70% threshold is used)

Test Case failure

- CSP/CBR integration is used when a test case fails.

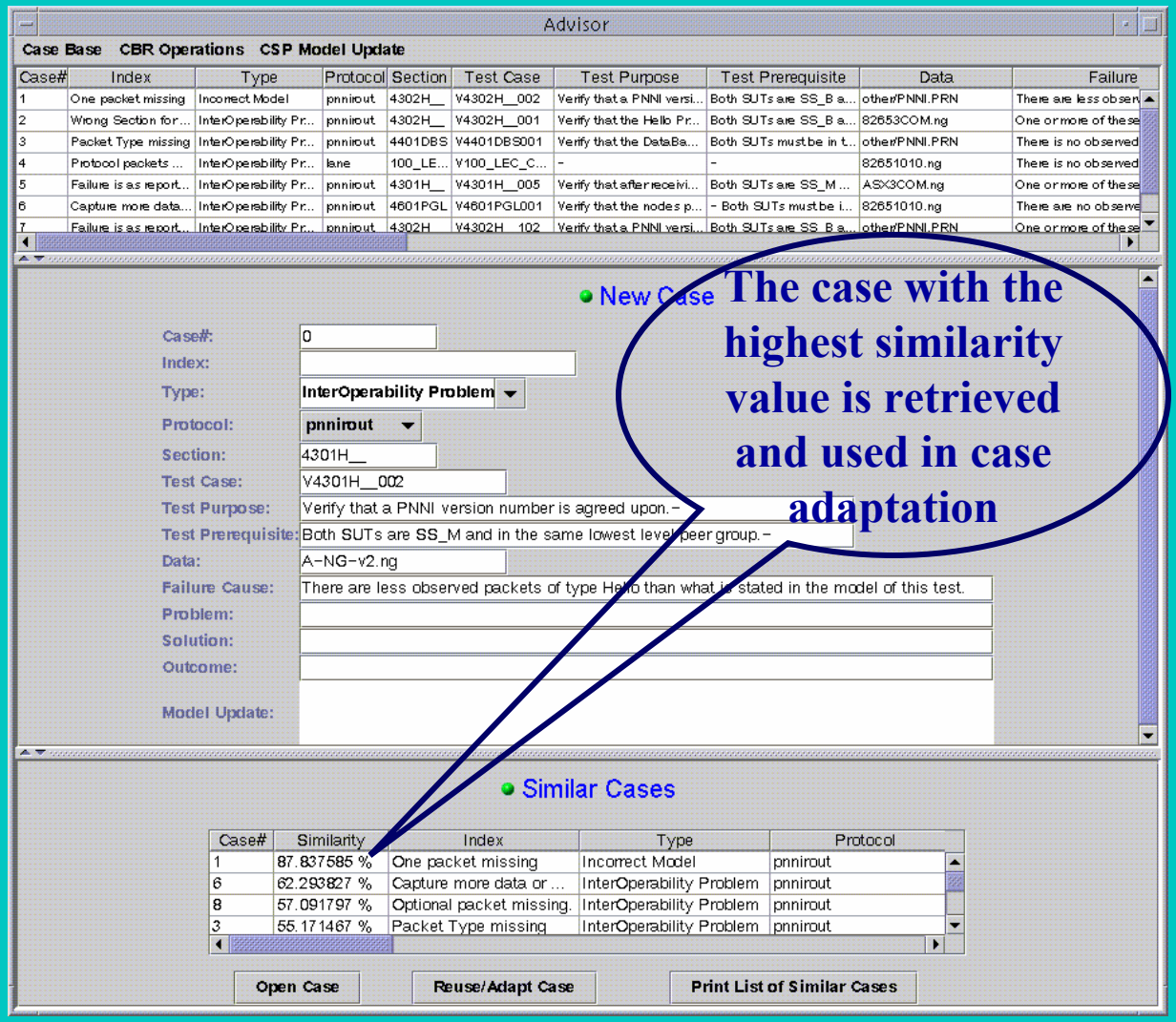


Advisor

Panel showing all cases stored in the ADIOP's case base

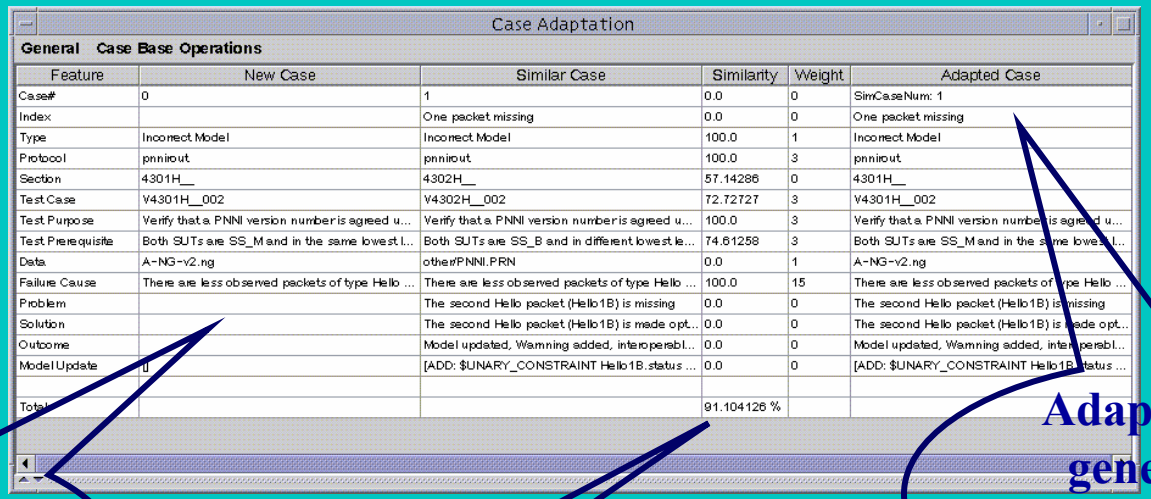
Panel showing the new case with all 14 features

Panel showing all cases ranked by similarity to the new case



The case with the highest similarity value is retrieved and used in case adaptation

Adaptation and Revised Case



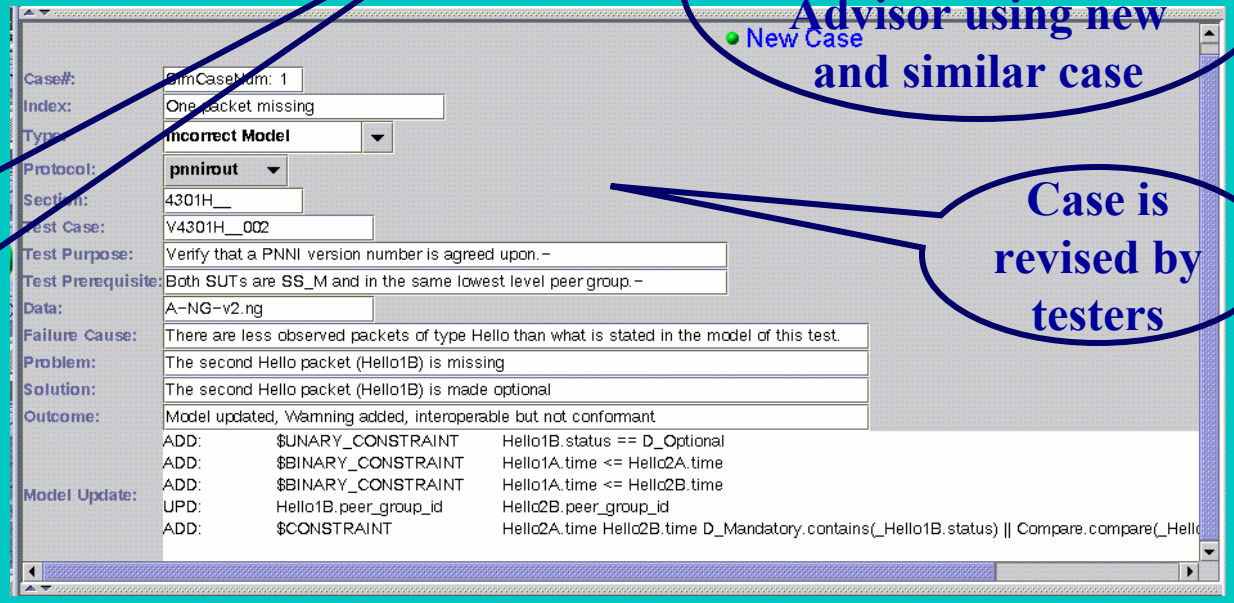
Feature	New Case	Similar Case	Similarity	Weight	Adapted Case
Case#	0	1	0.0	0	SimCaseNum: 1
Index		One packet missing	0.0	0	One packet missing
Type	Incorrect Model	Incorrect Model	100.0	1	Incorrect Model
Protocol	pnnirout	pnnirout	100.0	3	pnnirout
Section	4301H__	4302H__	57.14286	0	4301H__
Test Case	V4301H__002	V4302H__002	72.72727	3	V4301H__002
Test Purpose	Verify that a PNNI version number is agreed u...	Verify that a PNNI version number is agreed u...	100.0	3	Verify that a PNNI version number is agreed u...
Test Prerequisite	Both SUTs are SS_M and in the same lowest l...	Both SUTs are SS_B and in different lowest le...	74.61258	3	Both SUTs are SS_M and in the same lowest l...
Data	A-NG-v2.ng	other/PNNI.PRN	0.0	1	A-NG-v2.ng
Failure Cause	There are less observed packets of type Hello ...	There are less observed packets of type Hello ...	100.0	15	There are less observed packets of type Hello ...
Problem		The second Hello packet (Hello1B) is missing	0.0	0	The second Hello packet (Hello1B) is missing
Solution		The second Hello packet (Hello1B) is made opt...	0.0	0	The second Hello packet (Hello1B) is made opt...
Outcome		Model updated, Warning added, interoperabl...	0.0	0	Model updated, Warning added, interoperabl...
Model Update	[]	[ADD: $UNARY_CONSTRAINT Hello1B.status ...	0.0	0	[ADD: $UNARY_CONSTRAINT Hello1B.status ...
Total			91.104126 %		

New case content can be modified by testers

Adapted case is generated by Advisor using new and similar case

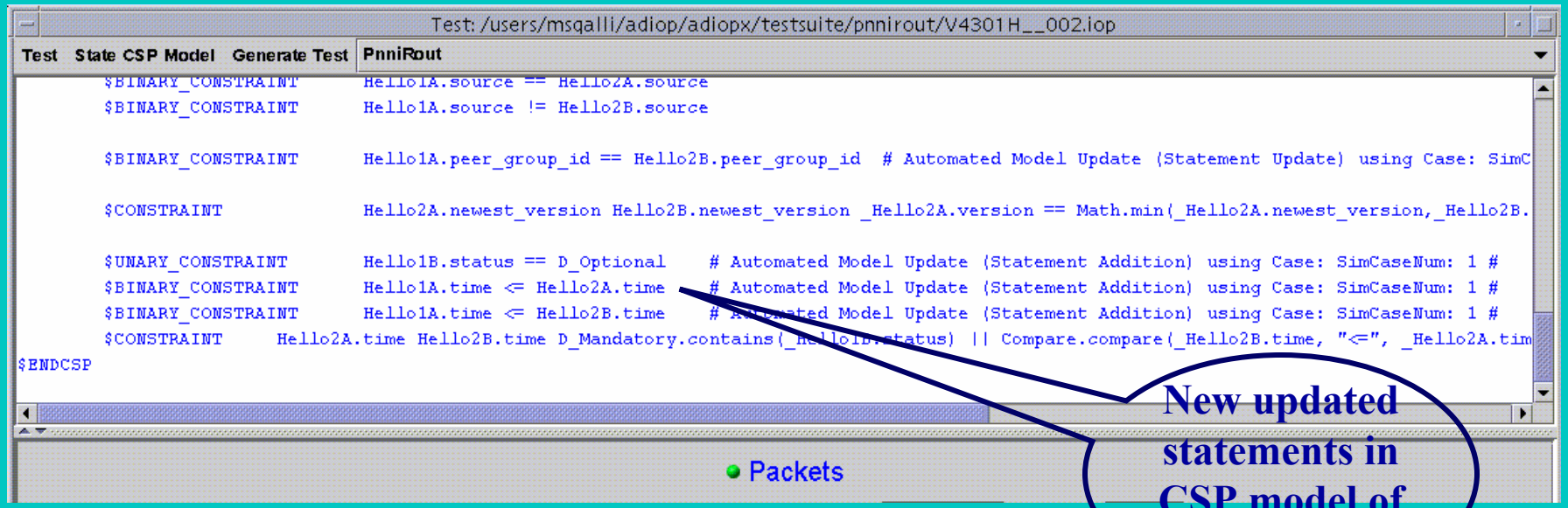
Advisor computes the new similarity value and update the Adapted case content

Case is revised by testers



Updating CSP Models

- Functionality to update models is stored in the "Update Model" feature of cases.
- Language integrates with CSP modeling:
  - ADD, DEL, UPD

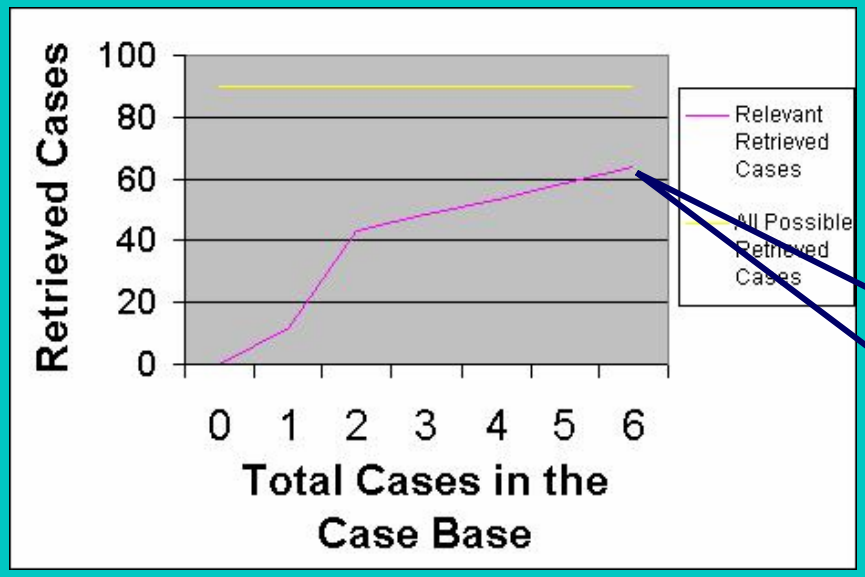


Improving Explanations

- Incorrect models generate incorrect explanations
- If inference does not lead to an explanation, the explanation provided by search in case of failure contains the violated constraints and is not useful
- The explanation provided by Diagnosis may be incomplete when only the problem is diagnosed. Cases can store information about how to resolve the interoperability problem found.
- Advisor provides useful explanations in these cases by retrieving similar previous situations.

Evaluation – Debugging

- 10 real-world captured data were used from two protocols
- Run only test cases that belong to the protocol used
- 90 test cases executed
- 6 cases stored in the case base (1 case for debugging models)
- These test cases were run using 1 case, 2 cases, and 6 cases



In 64 test cases out of 90, ADIOP retrieved relevant cases

Evaluation – Debugging

- CBR System
  - Recall = 88%, Precision = 71%
  - Similarity measure is off by 10%
- Learning
  - Out of 54 test cases with non-useful explanation using diagnosis, 33 can be explained using Advisor, an improvement of more than 60%
- Model Updates
  - Case 1 was used to update CSP models of 12 test cases

Related work – CSP/CBR integration

- CSP supports CBR:
  - Case adaptation: (Purvis & Pu 1995) and (Lee et al. 1997).
  - Case retrieval: (Bilgic & Fox 1996).
- CBR supports MBR:
  - (Portinale & Torasso 1995)
  - (Van Someren, Surma & Torasso 1997)
  - (Karamouzis & Feyock 1992) where CBR/MBR integration enhances MBR by the CBR capacity to contribute new links into the causality model.
- In ADIOP,
  - CBR supports CSP by debugging models, and CBR accounts for errors in CSP models of test cases.
  - CBR improves on the explanation of CSP diagnosis.
  - The case feature for model update is formalized as a CSP. Thus, case representation uses CSP.

Summary

- CBR is used to debug and update CSP models and compensate for incompleteness and incorrectness
- Cases include information about updating CSP models using a similar language to the CSP modeling language
- CBR improves on problem diagnosis and explanation provided by CSP
- CSP models of interoperability test cases are used as the baseline and cases provide an addition to models for capturing new experiences

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Discussion